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**SELF-DISTRACTING AND FIXATING BONE
BODY IMPLANT, VERTEBRAL INTERBODY
IMPLANT AND METHOD**

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INVENTOR

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1 SELF-DISTRACTING AND FIXATING BONE
2 BODY IMPLANT, VERTEBRAL INTERBODY
3 IMPLANT AND METHOD

4 TECHNICAL FIELD

5 This disclosure relates to surgical joining of bone bodies, and more
6 particularly to instruments, implants and methods for instant fixation,
7 distraction, and staged bone fusion or arthrodesis of bone bodies, such as
8 spinal vertebrae.

9
10 BACKGROUND OF THE INVENTION

11 This invention was specifically developed for the surgical joining of
12 bone bodies, such as the fusing of contiguous spinal vertebrae so as to
13 stabilize and prevent relative motion often resulting from a degenerative
14 disc condition. Although the immediate effort leading to this disclosure
15 is directed toward the lumbar, thoracic and cervical spine (anterior or
16 posterior in approach), the described vertebral implants for immediate
17 fixation and staged stabilization leading to arthrodesis (bone fusion) of
18 bone bodies may be used in a bone fracture or osteotomy to fuse
19 together resulting bone bodies, and across one or more joints or
20 articulations. Furthermore, the implants may be used in the lumbar,
21 thoracic and cervical spine.

22 The use of fixation plates and screws to hold together disunited
23 bone bodies has long been known to facilitate arthrodesis or bone-to-

1 bone union, such as bone fusion, and healing of fractured bones.
2 Typically, the separate bone bodies are formed when a single bone
3 fractures, requiring bone reunion. Plates are secured across a fracture
4 region with screws, joining together the bone bodies. The plates hold
5 the bone bodies together in proximate relation, facilitating bone growth
6 and fusion therebetween. In this manner, the bone bodies are supported
7 in close proximity, or in direct contact which facilitates fusion
8 therebetween. For cases where it is impossible to fixture together bone
9 bodies internally of a patient's skin, external fixation is used. For
10 external fixation, threaded pins are rigidly secured into each bone body.
11 The pins, which extend outwardly of a patient's skin, are fixtured
12 together with an external fixation device, placing the bone bodies in
13 adjacent proximate position to promote healing therebetween. However,
14 these techniques are not practical for certain joints such as joints formed
15 between spinal vertebrae. Therefore, a significant number of stabilizing
16 implants have been designed for joining together contiguous vertebrae.

17 One early technique for achieving arthrodesis between adjacent
18 vertebrae across a joint or articulation is the well-known Cloward
19 Technique for use in the human cervical spine. A solitary dowel of
20 bone is tapped into place in a prepared circular bed that is smaller than
21 the dowel of bone. The dowel acts as a wedge, distracting the
22 surrounding soft tissues of the joint, and separating the bone bodies or
23 vertebrae joined there along. The intervertebral disc substantially

1 comprises the soft tissues of the joint. The dowel of bone is inserted,
2 or wedged into place, providing its own stability by putting an annulus
3 of the disc on stretch. Additionally, simple friction of the inserted
4 dowel between adjacent vertebral bodies stabilizes axial dislocation.
5 However, a second surgical procedure must be performed to extract or
6 harvest the dowel of bone, substantially adding trauma to the procedure,
7 increasing costs, as well as increasing the threat of infection to the
8 patient. Alternatively, bank bone from human donors can be used, but
9 bank bone is less osteogenic and may introduce infection, or even
10 transmission of Acquired Immune Deficiency Syndrome (AIDS) or
11 hepatitis. Furthermore, bone morphogenic protein, hydroxy apatite, or
12 other bone stimulating material may be utilized. Additionally, there has
13 been a need to ensure the implant remains axially secured which has
14 lead to further developments.

15 A step forward from the Cloward Technique was provided by
16 Bagby (U.S. Patent No. 4,501,269) wherein a metal dowel uses the same
17 principle. A perforated cylindrical hollow implant is inserted between
18 prepared surfaces across a vertebral joint. The inserted implant
19 immediately stabilizes the joint by spreading the bony surfaces apart in
20 wedged opposition to surrounding tissue. This initial stabilization is
21 more substantial because a metal dowel, unlike a bone dowel, will not
22 be absorbed or fatigue in use. Over time, fusion occurs through and
23 around the implant which is filled with bone fragments. Use of the

1 metal dowel eliminates the need for a second operation to harvest a
2 dowel of bone. Bone fragments to be inserted in the implant are
3 retrieved during preparation of the circular beds in each vertebra.
4 Furthermore, such a metal implant avoids the disadvantage of having to
5 use bone bank to obtain donor bone. The Bagby implant described in
6 U.S. Patent No. 4,501,269 has a smooth outer surface, interrupted only
7 by numerous openings or fenestrations through which bone ingrowth and
8 through growth can occur. Ends of the implant are substantially closed,
9 with one end receiving an end cap such that bone fragments are
10 contained therein. Bone morsels or bone grafts are typically harvested
11 when preparing the circular bed in each vertebra, after which they are
12 placed into the fenestrated metal cylindrical implant. The Bagby implant
13 is then driven or tapped into place in a manner similar to the placement
14 of Cloward's Bone Dowel, which was solely directed for use in the
15 cervical spine. However, the original Bagby implant relies completely
16 upon stretch of the annulus to stabilize the vertebrae during bone
17 remodeling and fusion.

18 Improvements have also been made to "Cloward's Technique"
19 wherein two dowel bone grafts are posteriorly inserted (Wiltberger's
20 Technique) between adjacent lumbar vertebral bodies. Furthermore,
21 threaded surfaces have been added to such bone grafts in order to keep
22 the grafts in place (Otero-Vich German Application Number 3,505,567,
23 published June 5, 1986). More recently, a number of U.S. Patents have

1 proposed combining the threaded features from threaded bone grafts with
2 a metal implant, resulting in rigid threaded implant structures for
3 placement between adjacent spinal vertebrae.

4 One threaded metal fusion implant disclosed in Michelson (U.S.
5 Patent No. 5,015,247) provides a cylindrical fusion implant having an
6 outer diameter sized larger than the space between adjacent vertebrae to
7 be fused. Threads provided on the exterior of the member engage the
8 vertebrae to axially secure the implant therebetween. The implant has
9 a plurality of openings configured along the cylindrical surface to
10 promote bone ingrowth. However, the threads per se of the implant do
11 not function as a fastener to fix together the adjacent vertebral bodies.
12 Instead, the implant functions as a wedge, imparting a distraction force
13 across the disc which stabilizes the articulation formed therebetween by
14 stretching the annulus of the disc. In fact, the threaded implant relies
15 solely on the annulus to provide stabilization between the vertebrae, in
16 direct response to wedge-induced distraction created therebetween.
17 Distraction of the annulus stabilizes the two vertebrae, enabling ingrowth
18 to later occur within the implant. Therefore, through-growth and fusion
19 (arthrodesis) occur between the adjacent vertebrae subsequent thereto
20 depending on the immobilizing potential of an intact healthy annulus
21 which may or may not be present.

22 Several additional problems result from the provision of threads on
23 a cylindrical fusion implant. One problem results in that threads take

1 up additional space which makes implantation in areas having limited
2 anatomical space very difficult, such as in the posterior approach in the
3 lumbar spine. Additionally, the threads effectively make the wall
4 thickness greater which further separates bone provided inside the
5 implant with bone provided outside the implant, which can delay initial
6 bone union.

7 For bone fusion to occur with any of the above devices, the
8 invasion of new delicate blood vessels from the adjacent healthy bone is
9 necessary for the creation of new living interconnecting bone. Where
10 complete stabilization does not occur instantaneously upon implantation,
11 motion can disrupt the in growth of delicate blood vessels. Disruption
12 of the vessels then restricts or even prevents bone healing therebetween.
13 The same problem occurs with any of the above mentioned implant
14 techniques, including the threaded techniques of Otero-Vich and
15 Michelson. Even when the annulus is completely on stretch, the threads
16 per se of these constructions do not function in the manner of
17 conventional screws, extending through one object and into another.
18 Namely, they do not function to fasten together adjacent bodies by
19 coaction of the implant with each body. For example, the threads
20 merely act as a series of ridges that engage with each adjacent bone
21 body, while the implant body functions as a wedge. The implant
22 distracts apart the vertebral bodies which stretches the annulus, and
23 stabilizes the articulation as a consequence thereof, while the thread

1 functions solely to prevent axial dislodgement. Furthermore, the presence
2 of threads requires the implant to be screwed in place via a torquing
3 process, instead of tapping the implant directly into position.

4 Hence, some recent designs have resulted in an implant that
5 produces immediate fixation per se between bone bodies following
6 insertion and independent of the annulus. Such designs show promise
7 particularly for cases where the annulus structure is substantially or
8 completely weakened or damaged at surgery. Where the annulus is
9 damaged so significantly as to lose structural integrity, the wedge-effect
10 of prior art threaded implants will not produce any distraction forces
11 across the annulus. Also, when the implant is used to arthrodesis and
12 change angulation, a healthy annulus cannot be totally corralled to be
13 placed on stretch. As a result, there is no form of stabilization or
14 fastening between bone bodies sufficient to enable the occurrence of
15 arthrodesis therebetween when the annulus is weakened or inadequate.
16 Additionally, there exist additional shortcomings with such recent designs
17 as discussed below.

18 One such design that produces immediate fixation is disclosed in
19 Bagby (U.S. Patent No. 5,709,683) as a bone joining implant having a
20 spline or undercut portion that engages in assembly with each bone body
21 to be joined. However, such design requires the preparation of bone
22 beds that are engaged in interlocking relation with a bone bed engaging
23 portion provided by such undercut portions.

1 Many of the previously described implants can be inserted between
2 vertebrae while such vertebrae are distracted with a distraction tool.
3 One such tool uses a threaded pin which is inserted laterally into each
4 bone body, with such pins being rigidly secured therein. Such tool
5 distracts the vertebrae by separating the pins and vertebrae which
6 stretches the annulus. A drill is then used to drill out bone beds within
7 the vertebrae, after which the implant is inserted therein. However, such
8 procedure does not always impart sufficient distraction and takes time
9 and space to implement.

10 Yet another group of implant designs provide distraction between
11 adjacent vertebrae, including U.S. Patent No. 5,665,122 to Kambin and
12 U.S. Patent No. 5, 702,455 to Saggat. Kambin teaches an expandable
13 intervertebral implant formed from several components that cooperate
14 with an expansion screw to distract adjacent vertebral bodies by
15 expanding two of the cage components relative to one another.
16 However, such design is formed from several discrete components that
17 are movably fastened together and which are susceptible of loosening and
18 misadjusting within a patient. Saggat teaches a spine stabilizing
19 prosthesis that is inserted within a cavity between vertebrae. Such
20 design forms a jacking screw adjustment member that expands apart a
21 pair of bearing members, each engaged with a respective vertebra.
22 However, such design is illustrated in use as being inserted within a
23

1 vertebral cavity that is formed by removal of a portion of a vertebra
2 such as is formed by a corpectomy.

3 Therefore, there is a present need to provide an implant device
4 that instantly fastens bone bodies together upon implantation, enhances
5 arthrodesis by encouraging bony fusion adjacent the implant, and imparts
6 distraction between adjacent bone bodies during insertion. There is also
7 a need to provide such a device that facilitates staged stabilization
8 leading to bone fusion, in a manner that is relatively simple, more
9 reliable, less complicated, has fewer parts, and leads to quicker and more
10 thorough bone fusion and remodeling therebetween. The final stage of
11 bone fusion through and around the implant substantially eliminates any
12 need for the implant to maintain the fusion, thus allowing the bone
13 union to provide primary support therebetween.

14 15 SUMMARY OF THE INVENTION

16 In accordance with one aspect of the invention, a bone joining
17 implant comprises a tubular body having an open leading end, an open
18 trailing end, and a central aperture; the open leading end communicating
19 with the central aperture and configured to entrap a bone projection
20 from each of a pair of adjacent bone bodies being joined together. The
21 bone projection is integrally formed from each bone body being joined,
22 and the implant houses bone graft material therein. The bone
23 projections and bone graft material cooperate to enhance arthrodesis.

1 Such implant directly and instantly stabilizes adjacent bone bodies by
2 entrapping the bone projections.

3 In accordance with a second aspect of the invention, a vertebral
4 interbody implant comprises a tubular body having an oblique outer
5 surface and a cylindrical inner surface, and a tapered portion extending
6 from a cylindrical leading end between the inner surface and the outer
7 surface. The cylindrical leading end is sized to be received within bone
8 beds of adjacent vertebrae being joined, and the tapered portion
9 operative to self-distract the vertebrae during insertion of the oblique
10 outer surface therebetween. The tapered portion, in combination with
11 the oblique outer surface, imparts indirect stabilization by commanding
12 an annulus between the adjacent bone bodies to tighten or stretch in
13 response to distraction of the adjacent bone bodies.

14 In accordance with a third aspect of the invention, a tubular
15 implant contains an aperture extending completely through the implant
16 having a substantially continuous inner diameter which facilitates x-ray
17 evaluation of bone healing within the implant, following implantation and
18 arthrodesis. Particularly, such aperture facilitates evaluation extending in
19 a direction along the axis of the tubular implant, generally in an anterior
20 to posterior direction.

21 In accordance with a fourth aspect of the invention, a single
22 tubular body implant is provided for implantation between the pair of
23 bone bodies. Such tubular implant caters to a reduced amount of

1 surgery in that a single implant serves the surgical purpose of two
2 implants, in selected cases.

3 In accordance with a fifth aspect of the invention, a tubular
4 implant includes a tubular body having an oblique outer surface and a
5 cylindrical inner surface that is configured to be received in conforming
6 implantable relation with a pair of bone bodies that are formed from a
7 single cylindrical cut taken between adjacent bone bodies. Upon
8 distraction, the cylindrical cut forms an obliquity between the adjacent
9 bone bodies which conforms in substantially compliant fit-up with the
10 oblique outer surface of the tubular implant. Such conforming fit-up
11 increases frictional stabilization between adjacent bone bodies by
12 generating a larger contact surface area therebetween. Furthermore, the
13 oblique outer surface mates with such bone bodies in a manner that
14 imparts a degree of lateral stabilization so as to prevent lateral
15 movement at the adjoining interfaces.

16 In accordance with a sixth aspect of the invention, a tubular
17 implant is provided with an open leading end and a central aperture in
18 a manner to entrap intact bone projections extending from each of a
19 pair of adjacent bone bodies. Such entrapment provides immediate, or
20 instant, fixation between the adjacent bone bodies in a manner that
21 caters to retention of the local bone bodies via the intact bone
22 projections. Furthermore, bone graft material, or chips, are provided
23 within the interior of the tubular implant so as to provide osteogenic

1 material that is placed inside the implant. Such osteogenic material is
2 preferably generated during preparation of the bone beds, which
3 eliminates the need to perform additional surgeries for obtaining foreign
4 bone graft material from other locations on a patient, or from another
5 patient.

6 7 BRIEF DESCRIPTION OF THE DRAWINGS

8 Preferred embodiments of the invention are described below with
9 reference to the following accompanying drawings.

10 Fig. 1 is a perspective view of a vertebral structure showing a
11 vertebral interbody implant embodying this invention;

12 Fig. 2 is a perspective view of a vertebral structure showing a pair
13 of vertebral interbody implants, similar to the implant depicted in Fig.
14 1, embodying this invention;

15 Fig. 3 is a simplified frontal view illustrating a pair of adjacent
16 vertebral bodies prepared with distraction pins;

17 Fig. 4 is a simplified frontal view corresponding to the view
18 depicted in Fig. 3, and illustrating a pair of adjacent vertebral bodies
19 distracted by a distraction tool (not shown) that applies forces to the
20 distraction pins;

21 Fig. 5 is a perspective view of a pair of adjacent vertebrae and
22 illustrating a drill guide and drill bit used to form a first bore used to
23 prepare bone beds within the vertebrae;

1 Fig. 6 is a perspective view of the pair of vertebrae of Fig. 5, and
2 illustrating a hole saw used with the drill guide to further prepare the
3 bone beds within the vertebrae by cutting a cylindrical kerf therein;

4 Fig. 7 is a simplified side view illustrating the hole saw of Fig. 6
5 cutting a cylindrical kerf within the pair of vertebrae;

6 Fig. 8 is a perspective view of an alternative hole saw usable with
7 a power tool for cutting a cylindrical kerf within the vertebral bodies of
8 Fig. 7;

9 Fig. 9 is a simplified sagittal view illustrating the alternative hole
10 saw usable with a power tool of Fig. 8 cutting a cylindrical kerf within
11 the pair of vertebrae;

12 Fig. 10 is a perspective view of a kerf cleaning/deburring tool for
13 cleaning debris from the cylindrical kerf formed within the vertebral
14 bodies;

15 Fig. 11 is a simplified sagittal view showing the kerf
16 cleaning/deburring tool of Fig. 10 and illustrating the removal of debris
17 from within the cylindrical kerf formed within the vertebral bodies.

18 Fig. 12 is a perspective view of the vertebral interbody implant of
19 Fig 1 for insertion within the prepared bone beds of Fig. 11;

20 Fig. 13 is a perspective view taken from the driven end of the
21 vertebral interbody implant of Fig. 12;

22 Fig. 14 is a side view of the vertebral interbody implant of Fig.
23 12;

1 Fig. 15 is a leading end view of the vertebral interbody implant
2 of Fig. 12;

3 Fig. 16 is a driven end view of the vertebral interbody implant of
4 Fig. 12;

5 Fig. 17 is an unrolled plan view of the outer peripheral surface of
6 the vertebral interbody implant of Figs. 12-16;

7 Fig. 18 a perspective view illustrating an implant insertion tool
8 usable for inserting the implant of Figs. 12-16;

9 Fig. 19 is a simplified frontal view illustrating a pair of vertebrae
10 that have bone beds prepared according to the steps depicted in Figs.
11 1-11 comprising a cylindrical kerf;

12 Fig. 20 is a simplified frontal view illustrating the vertebrae of Fig.
13 19 in a distracted position corresponding to the position generated by
14 inserting the implant of Figs. 12-16;

15 Fig. 21 is a simplified frontal view illustrating the vertebrae of Fig.
16 20 in a distracted position caused by inserting Applicant's implant of
17 Figs. 12-16;

18 Fig. 22 is a simplified sagittal view taken along the centerline of
19 the implant of Figs. 12-16;

20 Fig. 23 is a surgical time simplified sagittal view of the implant
21 of Fig. 22 received within the prepared bone beds of adjacent vertebrae
22 and containing bone fragments immediately following implantation;
23

1 Fig. 24 is a healed time simplified sagittal view of the implant of
2 Fig. 22 received within the prepared bone beds of adjacent vertebrae and
3 illustrating the vertebra following bone remodeling and reorganization and
4 showing arthrodesis;

5 Fig. 25 is a coronal view of the implant and healed bone
6 comprising vertebrae and taken along line 25-25 of Fig. 24 and showing
7 arthrodesis;

8 Fig. 26 is a perspective view of an alternatively constructed
9 vertebral interbody implant similar to the embodiment depicted in Figs.
10 1-25 for insertion within the prepared bone beds of Fig. 11; and

11 Fig. 27 is a frontal view of the vertebral interbody implant of Fig.
12 26.

13 14 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

15 This disclosure of the invention is submitted in furtherance of the
16 constitutional purposes of the U.S. Patent Laws "to promote the progress
17 of science and useful arts" (Article 1, Section 8).

18 A preferred embodiment bone joining implant in accordance with
19 the invention is first described with reference to Figures 1, 12-18 and
20 21-25. Such an implant is described further below with respect to an
21 open-ended vertebral interbody implant having instant fixation in the
22 form of a leading open end and self-distraction features in the form of
23 a cylindrical inner surface and an oblique outer surface. The fixating

and self-distracting implant is designated in Figures 1, 12-18 and 21-25 generally with reference numeral 10. An alternative implementation comprising a pair of somewhat smaller sized implants 110 are depicted in Figure 2. Yet another alternative implementation comprises a substantially cylindrical tubular implant 210 depicted in Figures 26 and 27.

As shown in Figures 1, 12-18 and 21-25, implant 10 comprises a rigid, unitary body having a cylindrical leading edge 86 and an oblique outer surface 90, with an open leading end 96 (see Figs. 12-16). As shown in Figure 1, implant 10 is inserted within an aperture 18 formed between a pair of adjacent vertebral bodies 12 and 14 within a vertebral column 16.

As shown in Figure 1, aperture 18 is prepared within vertebral bodies 12 and 14, and disc 16, according to the procedure and tools depicted in Figures 5-11 described below in further detail. Aperture 18 forms a pair of vertebral bone bodies 22 and 24 that are formed to have a cylindrical configuration comprising a cylindrical kerf 158 (see Fig. 19). A leading cylindrical end of implant 10 is inserted into aperture 18, causing annulus 20 to distract as implant 10 is inserted therein (see Figs. 19-21 below). A leading open end 96 (see Fig. 12) of implant 10 entraps an intact living bone projection 168 and 170 on each respective vertebral body (see Figs. 19-22) which imparts immediate fixation between adjacent vertebral bodies 22 and 24 upon implantation.

More particularly, vertebrae 12 and 14 comprise neighboring bone bodies of a vertebral column 16 (see Fig. 1). A resilient articulation or joint is formed between vertebra 12 and 14 by a disc 16 extending between vertebrae 12 and 14. Anatomically, the disc is made up of a central nucleus pulposus and an outer encircling annulus. The annulus and nucleus pulposus are composed of laminae of fibrous tissue and fibro-cartilage. The nucleus pulposus, located at the center of the disc, comprises a soft, pulpy, highly elastic substance. The annulus is formed from laminae of fibrous tissue extending in criss-crossing fashion to encircle the nucleus pulposus. Additionally, the intervertebral disc is adherent, by its cephalad and caudad surfaces, to a thin layer of hyaline cartilage that covers the top and bottom surfaces of adjacent vertebrae. In a healthy patient, adjacent vertebra 12 and 14 are spaced apart by disc 16. However, degenerative disc disease and localized trauma can cause degradation or complete loss of the soft tissue components between neighboring vertebrae. For example, the annulus can partially or completely tear which can seriously degrade the structural condition of the articulation. Additionally, fluid can escape from the nucleus pulposus. When any of the above happens, vertebrae 12 and 14, loaded by the normal weight bearing of a patient, are pressed into closer adjoining positions, which can result in pinching of nerves that extend from between vertebrae of the spinal column (not shown).

1 Therefore, there is a need to recover the disc spacing provided by
2 a normal healthy disc 20 by way of inserting implant 10. Furthermore,
3 there is a need to provide implant 10 with a fixation that instantly
4 interlocks adjacent vertebra 12 and 14 together upon being implanted.
5 Furthermore, there is a need for such an implant 10 that imparts
6 distraction to disc 20 upon insertion and that facilitates staged
7 stabilization resulting in arthrodesis to occur between the vertebral
8 bodies, following initial implantation. Even furthermore, there is a need
9 to instantly fix adjacent vertebrae together since relative motion can
10 otherwise cause pinching of nerve tissue.

11 As a result, implant 10 can be inserted, preferably in a central
12 location between adjacent vertebrae 12 and 14 of patients who have bad,
13 ruptured or degenerative discs. A pair of somewhat smaller sized
14 laterally positioned implants may also be used in chosen cases, as shown
15 in Figure 2. Furthermore, implant 10 can be axially oriented anterior
16 to posterior, or even laterally. In summary, implants 10 are adapted for
17 implantation between prepared bony surfaces or beds 22 and 24 and
18 across the articulation formed by disc 20. A typical implantation might
19 involve placement of one or more implants 10 as required in order to
20 stabilize and fix the joint during bone ingrowth and through-growth of
21 the implant structure. Bone growth is also accomplished outside of and
22 surrounding the implant.

1 Figure 2 illustrates an alternative implementation comprising a pair
2 of laterally positioned implants 110. Implants 110 are essentially
3 identical to implant 10 (of Fig. 1), but are sized smaller in dimension.
4 Such implementation enables correction of lateral spinal curvatures by
5 inserting a laterally positioned pair of implants 110 having different outer
6 dimensions into similarly sized bone beds between adjacent vertebrae.
7 Such dual implant implementation also imparts additional stability across
8 disc 20 over that provided by the single implant implementation depicted
9 in Figure 1.

10 However, such dual implant implementation uses individual implants
11 110 that are sized smaller than the single implant 10 of Figure 1. As
12 a result, such dual implant implementation uses smaller sized apertures
13 118 which do not invade as much cancellous bone as the apertures 18
14 (see Fig. 1) for the larger sized single implant implementation of Figure
15 1. A solitary implant 10 as shown in Figure 1 invades cancellous bone
16 since aperture 18 has a larger diameter. In contrast, the smaller sized
17 dual implants 110 of Figure 2 tend to invade mostly cortical bone on
18 the end plates. However, cancellous bone is more desirable for bone
19 growth during staged bony fusion since cancellous bone is more
20 osteogenic than cortical bone. New growth bone, or callus bone,
21 comprises soft cancellous bone that only becomes hard (cortical) over
22 time via action of Wolff's Law of maturity.
23

1 Figures 3 and 4 illustrate one technique for distracting an
2 articulation between adjacent vertebral bodies 12 and 14 by placing disc
3 20 under stretch. Such technique has been used with prior art vertebral
4 interbody implants and fusion cages to impart distraction, after which an
5 aperture 218 (see Fig. 3) is formed in the articulation into which an
6 implant is inserted. However, some relaxation typically occurs to disc 20
7 following insertion.

8 In contrast, Applicant's implant depicted in Figures 1 and 2
9 generates self-distraction during insertion. It is understood that
10 Applicant's invention can be implemented in combination with the
11 distraction technique taught in Figures 3 and 4 in order to further
12 impart distraction between vertebral bodies 12 and 14 by stretching disc
13 20.

14 As shown in Figure 3, a rigid metal pin 26 and 28 is inserted in
15 a lateral direction into each vertebra 12 and 14, respectively. Pins 26
16 and 28 are each formed from a cylindrical piece of rigid stainless steel
17 having a threaded leading end (not shown). Such pins 26 and 28 are
18 formed in a manner similar to Harrington rods, but are shorter in
19 overall length. Pins 26 and 28 are threaded into respective apertures
20 that have been pre-cut or drilled into vertebrae 12 and 14, respectively.
21 Preferably, pins 26 and 28 are inserted laterally into vertebrae 12 and
22 14 such that pins 26 and 28 are rigidly secured in parallel respective
23 relation separated by a spaced apart distance D_1 .

1 As shown in Figure 4, external distraction force is applied between
2 pins 26 and 28 by a distraction tool (not shown) so as to impart
3 distraction between pins 26 and 28 and vertebral bodies 12 and 14.
4 Several tools are understood in the art for distracting apart vertebral
5 bodies. One technique involves modifying a pair of forceps to receive
6 pins 26 and 28. U.S. Patent No. 4,898,161 to Grundei teaches another
7 variation of a distraction tool comprising a pair of forceps for pushing
8 apart vertebrae. According to the Grundei tool, pins are integrally
9 formed by the forceps for pushing apart adjacent vertebrae when jaws
10 on the forceps are spread apart. Such U.S. Patent No. 4,898,161 is
11 herein incorporated by reference as showing a distraction tool presently
12 understood in the art. Preferably, pins 26 and 28 are moved apart by
13 the distraction tool so that they remain in parallel relation. Accordingly,
14 vertebral bodies 12 and 14 are moved apart without imparting any
15 relative rotation therebetween. As a result, pins 26 and 28 are
16 distracted to a new spaced apart distance D_2 . Hence, vertebral bodies
17 12 and 14 are distracted apart a total distance $D_T = D_2 - D_1$.

18 Following distraction of vertebral bodies 12 and 14, an aperture
19 218 is formed cooperatively within vertebral bodies 12 and 14 and
20 further within disc 20 with a drill bit and/or saw. Such aperture 218
21 forms a pair of bone beds 222 and 224 that receive a prior art vertebral
22 interbody implant.
23

1 Optionally, an aperture 18 (as depicted in Figure 19) can be
2 formed within vertebral bodies 12 and 14 of Figure 4. Accordingly,
3 distraction D_T can be imparted between vertebral bodies 12 and 14 which
4 is in addition to the self-distraction that is generated by merely inserting
5 implant 10 of Applicant's invention between bodies 12 and 14 as
6 described below with reference to Figure 21.

7 Figures 5-11 illustrate the preparation of aperture 18 and bone
8 beds 22 and 24 within vertebral bodies 12 and 14, respectively (of Fig.
9 1). Such figures illustrate one technique for preparing a suitable pair
10 of bone beds within adjacent vertebrae 12 and 14 for receiving implant
11 10 (of Fig. 1) such that self-distraction and immediate fixation are
12 imparted between vertebral bodies 12 and 14.

13 Figure 5 depicts a tool guide 30 and a drill bit 38 that are used
14 to drill a bore 40 (see Figs. 6 and 7) into vertebral bodies 12 and 14
15 and disc 20. Bore 40 is drilled a sufficient depth into bodies 12 and
16 14 so as to leave intact living bone projections 168 and 180 (see Fig.
17 11) having sufficient size to impart instant fixation between bodies 12
18 and 14 upon insertion of implant 10.

19 As shown in Figure 5, tool guide 30 is first tapped into
20 engagement with vertebral bodies 12 and 14 by an alignment drive and
21 hammer (not shown). Sharp fingers or projections 32-35 engage and
22 enter the outer surfaces of bodies 12 and 14 which causes tool guide 30
23 to be rigidly and securely seated between bodies 12 and 14. In this

1 position, a central bore 36 of tool 30 is aligned in an anterior/posterior
2 direction. Bore 36 is sized to receive and guide a tool bit 38 in an
3 anterior/posterior direction through bodies 12 and 14 and annulus 20.

4 More particularly, drill bit 38 is driven in rotation by a drill (not
5 shown) so as to cut out bore 40 (see Fig. 7). One suitable drill
6 comprises a Hudson hand-driven manual drill. Alternatively, a power
7 drill can be used to drive drill bit 38. Typically, bore 40 is drilled with
8 sufficient depth into bodies 12 and 14 to extend between 30-70% of the
9 depth of cylindrical kerf 44 as shown in Figure 7. Kerf 44 is
10 subsequently cut using one or more of the tools depicted with reference
11 to Figures 6-11 as described below.

12 Figure 6 illustrates a hole saw 42 used in combination with tool
13 guide 30 to form part or all of a cylindrical kerf 44 (see Fig. 7). As
14 illustrated in Figure 7, hole saw 42 is used to cut a cylindrical groove
15 68 (see Fig. 9) to a depth approaching 90% of the finished depth of
16 kerf 44. Hole saw 42 is inserted into bore 40 such that a cylindrical
17 groove is cut in axial alignment with bore 40. Thereafter, oscillating
18 cylindrical blade 50 (of Figs. 8 and 9) is used to cut the remaining
19 depth of cylindrical groove 70 which corresponds to the final depth of
20 kerf 44 as shown in Figure 9. A hand-driven kerf cleaning/deburring
21 tool 72 is then used to clean debris 84 (see Figs. 10 and 11) from
22 cylindrical groove 70 which prepares and finishes kerf 44 therein.
23 Optionally, hole saw 42 (of Figs. 6 and 7) and/or oscillating cylindrical

1 blade 50 can be used to prepared kerf 44. Further optionally, kerf 44
2 can be formed solely by use of hand-driven tool 72.

3 As shown in Figures 6 and 7, hole saw 42 comprises a hollow saw
4 blade having a shank that is driven in rotation by a drill (not shown).
5 The cylindrical saw blade of hole saw 42 is inserted in bore 36 of tool
6 guide 30 during a cutting operation. Guide 30 directs hole saw 42 to
7 cut in an accurate anterior/posterior direction that is coaxial with bore
8 40 formed by drill bit 38 (of Fig. 5).

9 Figure 7 illustrates hole saw 42 during a cutting operation.
10 According to one implementation, hole saw 42 is used to cut to a depth
11 indicated by cylindrical groove 68 shown in Figure 9. Subsequently,
12 reciprocating cylindrical blade 50 (of Figs. 8 and 9) is used to further
13 and substantially form a remaining portion of kerf 44.

14 Figure 8 illustrates one suitable construction for a reciprocating
15 cylindrical blade 50 used in conjunction with hole saw 42 (of Figs. 6 and
16 7) and tool 72 (of Figs. 10 and 11) to form cylindrical kerf 44. More
17 particularly, cylindrical blade 50 comprises a specially constructed
18 reciprocating blade designed for use with an existing, or slightly modified,
19 Stryker hand-held saw 46. Several Stryker hand-held saws are
20 commercially available for producing reciprocating saw blade motion.
21 Stryker Corporation is located in Kalamazoo, Michigan, and develops,
22 manufactures, and markets speciality surgical instruments.
23

1 As shown in Figures 8 and 9, cylindrical blade 50 comprises a
2 hollow cylindrical metal tube with a leading end forming a plurality of
3 cutting teeth 62, and a trailing end forming an end wall 63. End wall
4 63 of Figure 9 contains a pair of small apertures 64 positioned above
5 a pair of enlarged apertures 66. Apertures 64 and 66 are sized and
6 positioned in end wall 63 so as to mount cylindrical blade 50 coaxially
7 about the axis of rotation generated by saw blade drive member 48 on
8 Stryker saw 46. Pins 56 and 58 interdigitate with apertures 64 and 66,
9 respectively to impart rotatable securement between blade 50 and drive -
10 member 48. A threaded hexagonal fastener 52 is received through a
11 bore 65 in end wall 63 and into a complementary threaded aperture 60
12 within drive member 48 so as to rigidly secure blade 50 onto drive
13 member 48 for reciprocation.

14 In operation, drive member 48 is driven in reciprocating pivotal
15 movement by saw 46, which imparts reciprocation to blade 50 and teeth
16 62 so as to generate cutting forces. Such cutting forces are directed
17 against an object such as vertebral bodies 12 and 14 and disc 20 as
18 shown in Figure 9. Cylindrical blade 50 is sized with a dimension close
19 to that of bore 36 of tool guide 30 such that saw blade 50 is axially
20 guided in coaxial relation within bore 40 (see Fig. 7) and cylindrical
21 groove 68 (see Fig. 9). Cylindrical blade 50 is used to cut all the way
22 from groove 68 and to groove 70 which is substantially the entire depth
23 of the finished kerf 44 (of Fig. 11).

1 Figure 10 illustrates one construction for a kerf cleaning/deburring
2 tool 72 used to remove debris 84 from within cylindrical groove 70 of
3 vertebral bodies 12 and 14 (see Fig. 11). Tool 10 includes a t-shaped
4 handle 74 and a hollow cylindrical cutting body 76 having an open end
5 terminating in a plurality of circumferentially spaced apart cutting teeth
6 78. A deep gullet, or throat, 82 is provided between adjacent teeth 78
7 for collecting debris that is removed when tool 10 is inserted and
8 rotated within cylindrical groove 70 (see Fig. 11).

9 Figure 11 shows tool 72 in partial breakaway view positioned to
10 clean out debris 84 from cylindrical groove 70. Tool 72 is inserted into
11 groove while handle 74 is rotated back and forth to impart back and
12 forth rotary movement to teeth 78 within groove 70. Debris 84 is
13 removed and cut from groove 70 by movement of teeth 78. Such debris
14 84 lodges in gullets and within the hollow interior of body 76. Tool 72
15 is then removed from groove 70 which also removes debris 84.
16 Furthermore, teeth 78 impart a final finished dimension to cylindrical
17 kerf 44 prior to inserting an implant therein.

18 Figure 12 illustrates self-distracting and fixating implant 10 in
19 perspective view. Implant 10 has a cylindrical leading edge 86 and a
20 trailing edge 88. An oblique outer surface 90 and a cylindrical inner
21 surface 92 are formed between edges 86 and 88. A central cylindrical
22 chamber, or aperture, 94 is formed within implant 10, between edges 86
23 and 88. Chamber 94 forms an open leading end 96 and an open

1 trailing end 98 within implant 10. Upon implantation, open leading end
2 96 entraps projections 168 and 170 as shown in Figures 21 and 22 which
3 imparts immediate fixation between vertebral bodies 12 and 14.

4 As shown in Figure 12-17, four discrete beveled retaining tabs 116
5 are formed on oblique outer surface 90 adjacent to trailing end 88.
6 Tabs 116 are positioned about surface 90 so as to engage within one of
7 the bone beds formed in the vertebral bodies being joined. Such fingers
8 have a ramped front face and a sharp rear edge that serves to facilitate
9 insertion of implant 10 between prepared bone beds, while preventing
10 dislodgement therefrom. More particularly the sharp rear edges of tabs
11 116 serve to engage with such bone beds, preventing inadvertent
12 dislodgement of implant 10 from between a pair of prepared bone beds.

13 As shown in Figures 12-15 and 17, a plurality of interruptions 102
14 are formed in cylindrical leading edge 86, and extending into a tapered
15 portion 104. Such interruptions comprise wedge-shaped removed portions
16 of tapered portion 104 which cooperate to form individual tapered fingers
17 100 extending from cylindrical leading edge 86. Interruptions 102 serve
18 to further collect any debris that still remains within cylindrical kerf 44
19 during insertion as shown in Figure 22.

20 Also shown in Figures 12-15 and 17, a plurality of fenestrations
21 112 are provided spaced apart and extending through the tubular wall
22 of implant 10. Such fenestrations 112 serve to facilitate bony ingrowth
23 and through growth, and generally staged fusion as discussed in

1 Applicant's issued U.S. Patent No. 5,709,683 incorporated herein by
2 reference. Additionally, a pair of slightly larger sized tool fenestrations
3 114 are provided along trailing edge 88 for receiving pins 144 and 146
4 of an insertion tool 120, as shown and described in greater detail below
5 with reference to Figure 18. Tool fenestrations 114 are positioned at
6 locations perpendicular to guide slots 106 and 108; namely, at the 3
7 o'clock and 9 o'clock positions. During insertion, guide slots 106 and
8 108 are used to visual guide placement of implant 10 so as to impart
9 self-distraction to adjacent vertebral bodies, as described in further detail
10 below.

11 Such bony ingrowth and through-growth occur following insertion
12 of implant 10 within bone beds defined by inner surfaces 160 and 164
13 and outer surfaces 162 and 166 as shown in Figure 23. More
14 particularly, remodeled bony ingrowth and through-growth are shown and
15 described below in Figures 24 and 25. Fenestrations 112 extend
16 substantially throughout the walls of tubular implant 10, particularly as
17 shown in Figure 17. Such fenestrations 112 offer avenues of ingrowth
18 of bone between vertebrae, which is stimulated by bone graft material
19 placed within a central chamber comprising cylindrical aperture 94 (see
20 Fig. 15). In this manner, fenestrations 112 serve to facilitate earlier and
21 more thorough ingrowth of bone within implant 10. Furthermore,
22 fenestrations 112 enhance overall through growth of bone through implant
23 10.

1 A pair of guide slots 106 and 108 are also provided on a trailing
2 end 88 of implant 10 to facilitate proper presentation and alignment
3 when inserting implant 10 between a pair of vertebral bodies. Guide
4 slots 106 and 108 are positioned at the 12 o'clock and 6 o'clock
5 positions during insertion, corresponding with superior and inferior
6 locations. Such positioning is crucial since implant 10 has an oblique
7 outer surface that is designed to impart distraction between adjacent
8 vertebra during insertion therebetween.

9 According to Figure 17, oblique outer surface 90 of implant 10 is
10 shown in an unrolled plan view to better depict layout of fenestrations
11 112, tool fenestrations 114, fingers 100, tabs 116 and guide slots 106 and
12 108. Tapered portion 104 is also shown extending along leading edge
13 86. Guide slots 106 and 108 are shown positioned along opposite
14 trailing edge 88.

15 One feature of Applicant's invention is provided by forming a
16 cylindrical leading edge 86, and an oblique outer surface 90. Edge 86
17 is inserted into an appropriately sized cylindrical kerf 44 (see Fig. 21),
18 and insertion pressure is applied sufficient to generate distraction
19 between adjacent vertebrae as leading tapered portion 104 is inserted
20 therein. Hence, vertebrae 12 and 14 are distracted following
21 implantation of implant 10 therebetween.

22 Figure 18 illustrates an insertion tool or instrument 120 configured
23 for loading implant 10 into prepared bone beds formed by kerf 44 and

1 bore 40 (see Fig. 11). More particularly, bone beds are provided by a
2 pair of inner surfaces 160, 164 and a pair of outer surfaces 162, 166
3 formed at least in part by kerf 44 as viewed in Figures 19 and 20.

4 Insertion tool 120 is formed from a driver 122 and a guide 124.
5 Guide 124 forms a threaded bore 125 in which driver 122 is received in
6 adjustable, threaded engagement via threaded portion 150 of driver 122.
7 An adjustment nut 126 cooperates with a lock nut 126 to enable
8 securement of driver 122 within guide 124 at a desired, threaded axial
9 location.

10 Once driver 122 has been threaded sufficiently into guide 124 to
11 cause pins 140 and 142 to be moved outwardly via contact with end 148,
12 nut 126 is tightened into engagement against trailing end 138.
13 Subsequently, lock nut 128 is tightened into engagement against nut 126.

14 A recessed mounting surface 130 is formed adjacent a leading end
15 137 of guide 124. Surface 130 is sized to slidably fit securely within
16 open trailing end 98 (see Figs. 13 and 16) of implant 10. Once
17 positioned over surface 130 and against a receiving shelf 134, implant 10
18 is locked onto guide 124 by outwardly biasing a pair of retaining pins
19 140 and 142 within tool fenestrations 114. Preferably, pins 140 and 142
20 are sized sufficiently to fit within tool fenestrations 144, but are
21 oversized relative to fenestrations 112 (of Figs. 12-17). Hence, pins 140
22 and 142 are sized to prevent misaligned mounting of implant 10 onto
23 insertion tool 120.

More particularly, driver 122 forms a driver pin 156 that extends within an enlarged bore 136 formed within guide 124. Bore 136 decreases in size immediately adjacent leading end 137 so as to form a reduced diameter bore 132. Bore 132 enables clearance of a beveled frustoconical end 148 of driver pin 156 during threaded adjustment between driver 122 and guide 124. Frustoconical end 148 mates in sliding engagement with a radially inwardly extending end of each pin 140 and 142. Such inward end of each pin 140 and 142 forms a complementary beveled end that mates for sliding engagement with end 148 as driver 122 is adjustably positioned within guide 124.

Pins 140 and 142 are retained for radially extending inward/outward movement within associated guide holes 144 and 146, respectively. More particularly, each pin 140 and 142 is retained within hole 144 and 146 via a press-fit rolled pin 141 and 143, respectively. Each rolled pin 141 and 143 passes through an elongated slot formed through each associated pin 141 and 143. In this manner, each pin 141 and 143 is allowed to slide within guide hole 144 and 146, respectively, but is prevented from becoming completely dislodged.

In order to facilitate insertion of implant 10, driver 122 has an enlarged driver handle 152 that terminates to form a driver end 154. Driver end 154 is shaped to facilitate impact with a hammer during insertion of an implant 10 between bone bodies. Furthermore, pins 140 and 142 cooperate with recessed mounting surface 130 and shelf 134 to

1 rigidly and securely retain implant 10 on tool 120, even where
2 considerable lateral loading might occur. Such lateral loading might
3 occur, for example, as a result of wiggling implant 10 and tool 120 while
4 attempting to insert ~~tool~~ 10 within a pair of prepared vertebrae. Upon
5 insertion, implant 10 traps adjacent vertebrae for immediate fixation,
6 within open leading end 96.

7 Once implant 10 has been inserted between bone bodies, nuts 126
8 and 128 are loosened, after which driver 122 is loosened or unthreaded
9 relative to guide 124 which enables pins 140 and 142 to retract.
10 Preferably, the outermost ends of pins 140 and 142 are chamfered to
11 facilitate removal of implant 10 from tool 120. Optionally, frustoconical
12 end 148 can be magnetized to impart retraction of pins 140 and 142 as
13 drive pin 156 is retracted within guide 124.

14 Figures 19 and 20 illustrate prepared vertebrae 12 and 14 prior to
15 insertion of an implant and after insertion of an implant of Applicant's
16 invention, respectively, but with the implant omitted for clarity. Figure
17 21 corresponds with Figure 20, but shows the details of implant 10
18 inserted in interlocking relation with vertebrae 12 and 14.

19 As shown in Figure 19, a pair of vertebrae 12 and 14 are retained
20 together with an intervertebral disc 20. An aperture 18 is formed
21 partially as a kerf 44, and generates bone beds in the form of inner
22 surfaces 160, 164 and outer surfaces 162, 166. A pair of intact bone
23 projections 168 and 170 are formed as a result extending from vertebrae

1 12 and 14, respectively. Such bone projections 168 and 170 are
2 entrapped within the open leading end 96 of implant 10 (see Fig. 12)
3 immediately upon insertion. Hence, instant fixation is provide upon
4 implant of such device. Furthermore, instant distraction is also
5 generated as a result of the oblique outer surface 90 of implant 10 (see
6 Fig. 12).

7 As shown in Figure 20, the forcible insertion of an implant
8 between bone bodies, or vertebrae, 12 and 14 causes self-distraction of
9 amount "D" which corresponds to the difference in diameter for
10 cylindrical leading edge 86 and the outermost dimension of oblique
11 surface 90 along the vertical direction, as shown in Figure 15.
12 Dimension "D" is shown slightly exaggerated in Figure 20 to more
13 clearly illustrate the self-distraction feature. In most applications, a
14 lumbar placement would generate approximately 5 millimeters of
15 distraction distance "D".

16 Figure 21 illustrates implant 10 inserted into vertebrae 12 and 14.
17 Due to the difference in wall thickness caused by the oblique outer
18 surface and cylindrical inner surface of implant 10, cylindrical kerf 44
19 only receives implant 10 snugly at the 12 o'clock (superior) and 6
20 o'clock (inferior) positions as shown in Figure 21. Tabs 116 are also
21 shown inserted into vertebrae 12 and 14 which ensures retention of
22 implant 10 therein, following implantation. Furthermore, the oblique
23 outer surface mates in conforming engagement with the prepared bone

1 beds in vertebrae 12 and 14 such that lateral bending and rotation is
2 resisted due to the increased frictional forces caused by close fit-up, and
3 due to non-cylindrical mating contact.

4 As shown in Figure 21, implant 10 generates self-distraction
5 between vertebrae 12 and 14, once implanted. The annulus is thereby
6 placed on stretch which further stabilizes instant fixation. The non-
7 cylindrical fit-up between implant 10 and vertebrae 12 and 14 cooperates
8 with the stretched annulus so as to impart rigid, instant fixation.
9 Furthermore, implant 10 stops further compression from occurring
10 between vertebrae 12 and 14. Likewise, implant 10 entraps bone
11 projections 168 and 170, which prevents any distraction from occurring
12 between vertebrae 12 and 14.

13 Figure 22 shows implant 10 during implantation between vertebrae
14 12 and 14, in a self-distorted position. Bone projections 168 and 170
15 are clearly shown entrapped within implant 10, which generates
16 immediate entrapment of projections 168 and 170, and fixation between
17 vertebrae 12 and 14. After removal and retraction of tool 124, bone
18 grafts, or morsels, 172 are then packed inside of implant 10, as shown
19 in Figure 23.

20 According to Figure 23, bone grafts 172 facilitate earlier bone
21 ingrowth and through growth. Similarly, fenestrations, as well as the
22 open leading and trailing ends, of implant 10 further facilitate such
23 ingrowth and through growth.

1 Figure 24 illustrates staged stabilization and fusion via Wolff's law,
2 wherein bone remodeling and reorganization has further fixed and fused
3 such adjacent vertebrae 12 and 14. The trabeculae relocate through
4 fenestrations to form a mature strengthening of the trabeculae.
5 Additional reorganization is provided by preparing bone beds that recess
6 implant 10 within vertebrae, and by providing bone graft material
7 thereabout at the time of implantation. Accordingly, additional bone
8 reorganization is facilitated outside of implant 10.

9 Figure 24 is a sagittal section and diagrammatic view through
10 implant 10 and vertebrae 12 and 14, illustrating reorganization of fused
11 bone material through implant 10. Histologic bone cell geometry is
12 shown in greater detail, corresponding in time with complete bone
13 remodeling. Lacunae and canals or voids 172 are formed between the
14 bone 174.

15 Figure 25 is a coronal and diagrammatic view taken perpendicular
16 to the view of Figure 24 along line 25-25. In such view, bone cells
17 have remodeled to form a definite elongated configuration extending
18 between vertebrae 12 and 14. Such remodeled bone through growth can
19 be seen between fenestrations on some sides of a patient, occurring from
20 cephalad to caudad, as well as between fenestrations along a diagonal
21 configuration of the patient, from cephalad to caudad.

22 Figures 26 and 27 illustrate an alternative embodiment self-
23 distracting and fixating implant 210. Figure 26 illustrates implant 210

1 in perspective view. Implant 210 is constructed similarly to implant 10
2 depicted in Figure 12. However, implant 210 is provided with a
3 cylindrical outer surface 290 containing at least one helical thread 291.
4 Implant 210 has a cylindrical leading edge 286 and a cylindrical trailing
5 edge 288. Cylindrical outer surface 290 and a cylindrical inner surface
6 292 are formed between edges 286 and 288. A central cylindrical
7 chamber, or aperture, 294 (see Fig. 27) is formed within implant 210,
8 between edges 286 and 288. Chamber 294 forms an open leading end
9 296 and an open trailing end 298 within implant 210. Upon
10 implantation, open leading end 296 entraps bone projections similar to
11 those shown in Figures 21 and 22 on implant 10. Accordingly, instant
12 fixation is provided between vertebral bodies.

13 Also shown in Figures 26 and 27, a plurality of interruptions 202
14 are formed in cylindrical leading edge 286, and extending into a tapered
15 portion 204. Individual tapered fingers 200 are formed by interruptions
16 202, along cylindrical leading edge 286. Interruptions 202 serve to
17 collect debris similar to the interruptions depicted for implant 10 of
18 Figure 12.

19 Although implant 210 does not include an oblique outer surface,
20 a tapered portion 104 extends along leading edge 286 so as to impart
21 a degree of distraction when inserted into the cylindrical kerf 44, shown
22 in Figure 20. However, the cylindrical threaded outer surface 290 will
23

1 not generate quite the same degree of distraction, and will not impart
2 the same degree of fit-up as will implant 10 of Figure 21.

3 Implant 210 also includes tool fenestrations 214 for facilitating
4 insertion with tool or instrument 120 of Figure 18. Furthermore, implant
5 210 includes a plurality of fenestrations 212 for facilitating bony ingrowth
6 and through growth following insertion of implant 210 within bone bodies
7 of adjacent vertebral bodies.

8 In compliance with the statute, the invention has been described
9 in language more or less specific as to structural and methodical
10 features. It is to be understood, however, that the invention is not
11 limited to the specific features shown and described, since the means
12 herein disclosed comprise preferred forms of putting the invention into
13 effect. The invention is, therefore, claimed in any of its forms or
14 modifications within the proper scope of the appended claims
15 appropriately interpreted in accordance with the doctrine of equivalents.
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